AN ANALYSIS OF THE AQUATIC INVERTEBRATES AND HABITAT OF THE LOWER GALLATIN RIVER AND SOUTH COTTONWOOD CREEK

GALLATIN COUNTY, MONTANA

September 2001 and September 2002

A report to

Gallatin Local Water Quality District
Bozeman, Montana

by

Wease Bollman
Rhithron Biological Associates
Missoula, Montana

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INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected from seven sites in September 2001 and in September 2002 on the lower Gallatin River and South Cottonwood Creek, Gallatin County, Montana, as well as data collected in September 2002 from two additional sites on South Cottonwood Creek, Gallatin County, Montana. Aquatic invertebrate assemblages were sampled by personnel from the Gallatin Water Quality District. Study sites lie within the Montana Valley and Foothill Prairies ecoregion (Woods et al. 1999). A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is " …a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment…" (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "… an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1995). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied is needed to assist in the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat parameters and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998) has recently studied the assemblages of the Montana Valley and Foothill Prairies ecoregion, and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to habitat assessment parameters, and consistent over replicated samples.

Habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by metals, other toxicants, high water temperatures, or high levels of organic and/or nutrient pollution might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment in an oligotrophic setting.

METHODS

Aquatic invertebrates were sampled by Gallatin Water Quality District personnel in September 2001 and September 2002. The purpose of the project is to provide an assessment for Total Maximum Daily Load development. Six sites on the lower Gallatin River and one site on South Cottonwood Creek were sampled in 2001. These same sites were sampled in 2002 along with two additional sites on South Cottonwood Creek. Two samples, considered replicates, were taken at each site. Site locations and sampling dates are indicated in Table 1. The sampling method employed was that recommended in the Montana Department of Environmental Quality (DEQ) Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998), consisting of a "traveling kicknet" method with one minute of effort applied for each replicate. In addition to aquatic invertebrate sample collection, habitat quality was visually evaluated at each site and reported by means of the habitat assessment protocols recommended by Bukantis (1998) for streams with riffle/run prevalence.

Table 1. Sampling sites and dates. Six sites on the Lower Gallatin River and three sites on South Cottonwood Creek. September 2001 and 2002. (Habitat sheets provided by GWQD personnel specify different latitudes/longitudes in 2001 and 2002 for three of the nine sites).

Site designation	Site name	Sampling Dates	Location	GPS Latitude / Longitude
LGALR02	Highway 191	9/10/01 9/19/02	Lower Gallatin River: above Highway 191 bridge	45º 31' 11" / 111º 15 ' 02" 45º 31' 08" / 111º 15 ' 05"
LGALR03	Williams	9/10/01 9/19/02	Lower Gallatin River: above Williams bridge	45º 32' 25" / 111º 14 ' 04"
LGALR06	Axtell	9/11/01 9/10/02	Lower Gallatin River: below Axtell bridge	45º 37' 24" / 111º 12 ' 18"
LGALR07	Shedd's	9/11/01 9/11/02	Lower Gallatin River: above Shedd's bridge	45º 40' 16" / 111º 12 ' 31"
LGALR10	*Central Park	9/12/01 9/11/02	Lower Gallatin River: above Central Park	45º 49' 23" / 111º 16 ' 20" 45º 49' 22" / 111º 16 ' 20"
LGALR13	Logan	9/12/01 9/11/02	Lower Gallatin River: above Logan bridge	45º 53' 09" / 111º 26 ' 30" 45º 53' 08" / 111º 26 ' 28"
SCTNC01	†Trail	9/13/01 9/13/02	South Cottonwood Creek: @ Trail bridge	45º 32' 04" / 111º 04 ' 50"
SCTNC05	Law	9/13/02	South Cottonwood Creek @ Law Rd. below Headgate/Shockley Property	45º 35' 19" / 111º 10 ' 01"
SCTNC06	Gooch	9/13/02	South Cottonwood Creek @ Gooch Hill Rd. above Highway 191 bridge	45º 35' 51" / 111º 11 ' 45"

* In the report provided for the 2001 data, this site was originally identified as CP.
† In the report provided for the 2001 data, this site was originally identified as S. Cott.

Evaluated habitat features include instream conditions, larger-scale channel conditions including flow status, streambank condition, and extent of the riparian zone. Scores were assigned in the field to each habitat measure, and these scores were totaled and compared to the maximum possible score to give an overall assessment of habitat.

Aquatic invertebrate samples and associated habitat data were delivered to Rhithron Biological Associates, Missoula, Montana, for laboratory and data analyses. In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

To assess aquatic invertebrate communities in this study, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998) was used. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics, which have been shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used in this study were selected because both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998). In addition, they are relevant to the kinds of impacts that are present in the Gallatin River basin. They have been demonstrated to be more variable with anthropogenic disturbance than with natural environmental gradients (Bollman 1998). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.
2. **Plecoptera (stonefly) taxa richness.** Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.
3. **Trichoptera (caddisfly) taxa richness.** Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.
4. **Number of sensitive taxa.** Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998).
5. **Percent filter feeders.** Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy

appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* sp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

6. **Percent tolerant taxa.** Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

Table 2. Metrics and scoring criteria for bioassessment of streams of western Montana ecoregions (Bollman 1998).

	Score			
metric	**3**	**2**	**1**	**0**
Ephemeroptera taxa richness	> 5	5 - 4	3 – 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 – 5	5.01 - 10	10.01 – 25	> 25
Percent tolerant taxa	0 – 5	5.01 - 10	10.01 – 35	> 35

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

Table 3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis, 1998).

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman, unpublished data). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.
- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are

included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman, unpublished data).

- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman, unpublished data).

2002 RESULTS

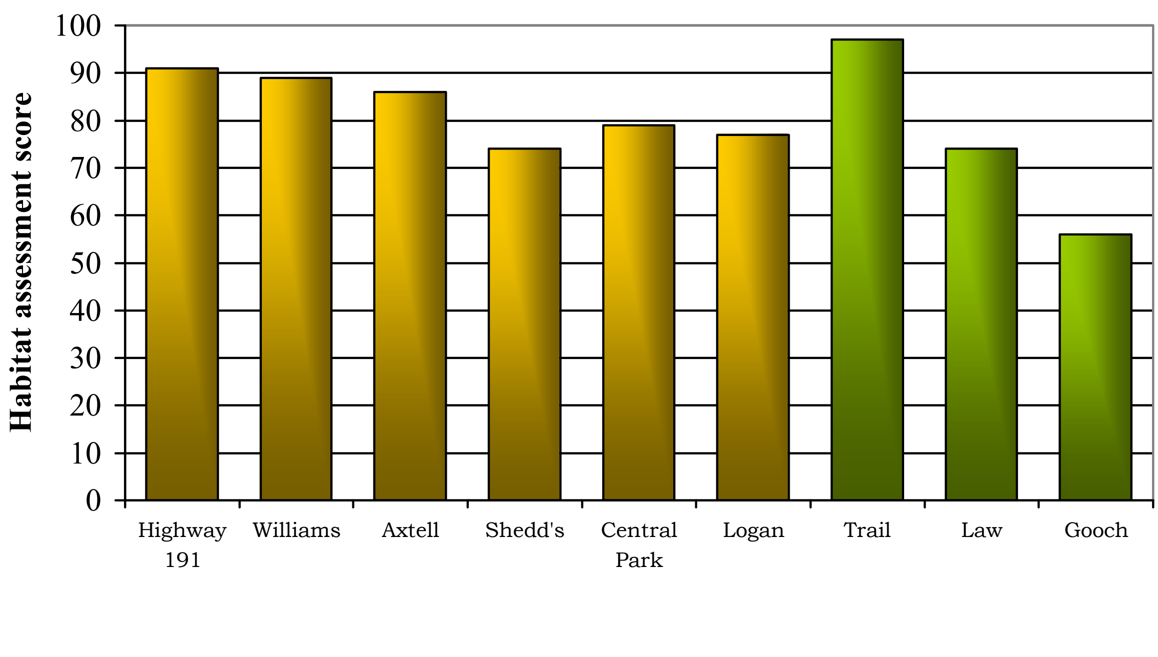
Habitat assessment

Gallatin River sites

Figure 1 compares habitat assessment results for the 9 sites visited in September 2002. Table 4 itemizes the evaluated habitat parameters and shows the assigned scores for each. In 2002, habitat assessments generally gave positive results; scores suggest that overall conditions were optimal or sub-optimal at all 9 sites.

At the Highway 191 bridge, all evaluated instream habitat parameters were judged optimal. Large boulders added to benthic substrate diversity. Flow conditions met expectations. Field notes and scores assigned to streambank parameters at this site indicate that disturbance to bank stability and vegetative cover was appraised on one bank; cattle and fishing access to the stream were noted. The riparian zone width appeared to be somewhat abbreviated on one side of the channel. Overall habitat conditions at this site rated an optimal classification.

Figure 1. Total habitat assessment scores for six sites on the Lower Gallatin River and three sites on South Cottonwood Creek. September 2002.



Above Williams bridge, streambanks were judged essentially stable, although scores indicate that some disruption of vegetative protection was evident; irrigated hayfields at streamside were reported. Instream habitat was apparently in optimal condition, with minimal sediment deposition and good substrate diversity. Flow status was considered optimal, as were overall habitat conditions.

At the site below Axtell bridge, channel alteration associated with the bridge was noted, and flow status at this site was considered sub-optimal. Instream habitat parameters all merited optimal scores, and only minor disruption to streambank stability was noted. The disruption was attributed to the fishing access present at the site. Overall habitat conditions were rated optimal.

Above Shedd's bridge, scores indicate that instream habitat was apparently affected by fine sediment deposition and sub-optimal diversity of benthic substrate particles. Field personnel noted that heavy road construction work may have resulted in sediment inputs to the river. Rip-rap along channel edges altered natural morphology, and resulted in lower than expected scores for streambank vegetation and riparian zone width. Bank stability, however, was judged optimal. Overall habitat conditions rated sub-optimal.

Overall conditions at Central Park were judged optimal; instream parameters were all within expectations for good riverine habitat. Irrigation diversions were reported both above and below the evaluated site, with some minor associated channel alteration. Flow status was reported to be sub-optimal at this site. A large cobble/gravel bar apparently destabilized the streambank along one side of the channel, and vegetative protection was disrupted by the presence of noxious weeds. The riparian zone width was somewhat abbreviated on one side.

Above Logan bridge, sub-optimal overall habitat conditions were assessed. Reduced riffle area was reported. Heavy sediment deposition was noted in backwaters, but it apparently did not substantially affect the flowing reaches; instream habitat conditions scored optimally. Rip-rap along one bank reduced the bank stability score, and noxious weeds reduced bank vegetative protection on both streambanks. Abbreviated riparian zone width on one side of the channel was noted.

South Cottonwood Creek sites

Overall habitat conditions at Trail bridge, the uppermost site on South Cottonwood Creek, rated an optimal classification. All instream habitat parameters were judged to be in excellent conditions, and streambank and riparian zone features appeared to be undisturbed. Flow conditions at this site were rated optimal.

Farther downstream, overall habitat conditions apparently deteriorated; the site below Law Road was classified as sub-optimal. Fine sediment deposition was noted and substrates were mildly embedded. Channel morphology was reported and attributed to an upstream road crossing and an irrigation headgate. Some streambank erosion was observed upstream of the sampling site, and horse access to banks resulted in closely cropped vegetation. Grasses and a few senescent cottonwood trees characterized the riparian zone vegetation.

Among the evaluated reaches, the site above Highway 191 (Gooch) on South Cottonwood Creek rated the lowest overall habitat assessment score; sub-optimal conditions were reported. Moderate fine sediment deposition and substrate embeddedness apparently diminished the quality of instream habitats. Flow status was assessed as marginal; field notes report "small amount of flow this year." Streambanks were noted to be moderately stable, with noxious weeds reducing the vegetative protection. The riparian zone was apparently mildly abbreviated on both sides of the channel.

Table 4. Stream and riparian habitat assessment. Six sites on the Lower Gallatin River and three sites on South Cottonwood Creek. September 2002.

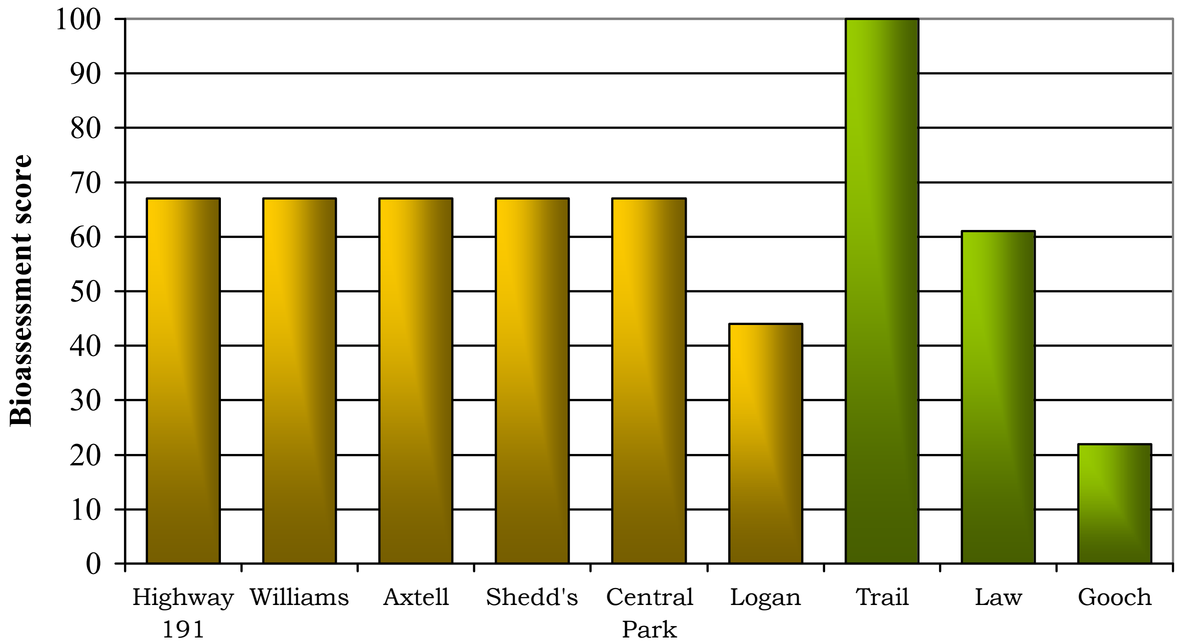
		Gallatin River sites						*South Cottonwood Creek sites*		
Max. possible score	**Parameter**	Highway 191	Williams	Axtell	Shedd's	Central Park	Logan	Trail	Law	Gooch
10	Riffle development	9	9	8	7	9	4	10	9	3
10	Benthic substrate	10	10	9	8	10	9	10	9	9
20	Embeddedness	18	19	19	17	18	17	19	15	7
20	Channel alteration	20	20	15	13	18	18	19	14	16
20	Sediment deposition	19	18	19	15	16	17	19	11	6
20	Channel flow status	18	16	15	16	12	18	18	15	7
20	Bank stability: left / right	9 / 8	10 / 8	8 / 9	9 / 10	8 / 5	9 / 5	10 / 10	7 / 8	7 / 7
20	Bank vegetation: left / right	9 / 8	8 / 6	9 / 9	5 / 7	9 / 6	6 / 6	10 / 10	5 / 9	6 / 8
20	Vegetated zone: left / right	8 / 10	9 / 9	9 / 9	2 / 9	9 / 6	5 / 9	10 / 10	9 / 8	7 / 7
160	Total	146	142	138	118	126	123	155	119	90
	Percent of maximum CONDITION*	**91% OPT**	**89% OPT**	**86% OPT**	**74% SUB**	**79% OPT**	**77% SUB**	**97% OPT**	**74% SUB**	**56% SUB**

*Condition categories: Optimal (OPT) > 80% of maximum score; Sub-optimal (SUB) ; 75 - 56%; Marginal (MARG) 49 - 29%; Poor <23%. (Plafkin et al. 1989.)

Bioassessment

Figure 2 summarizes bioassessment scores for aquatic invertebrate communities sampled at the 9 sites in this study. Bars represent scores based on metric values averaged over 2 replicate samples taken at each site. Table 5 itemizes each contributing metric and shows individual metric scores for each replicate. Tables 3a and 3b show criteria for use-support and impairment classifications categories recommended by Montana DEQ.

Figure 2. Total bioassessment scores for six sites on the lower Gallatin River and three sites on South Cottonwood Creek, September, 2002. Total scores are based on average metric values for two replicate samples. Sites are described in Table 1.



When this bioassessment method is applied to these data, five Gallatin River sites upstream of Logan shared remarkably similar bioassessment results. Scores for these sites indicate partial support of designated uses and slight impairment of biologic condition. Downstream, at Logan, bioassessment results suggest moderate impairment of biotic integrity and partial use support.

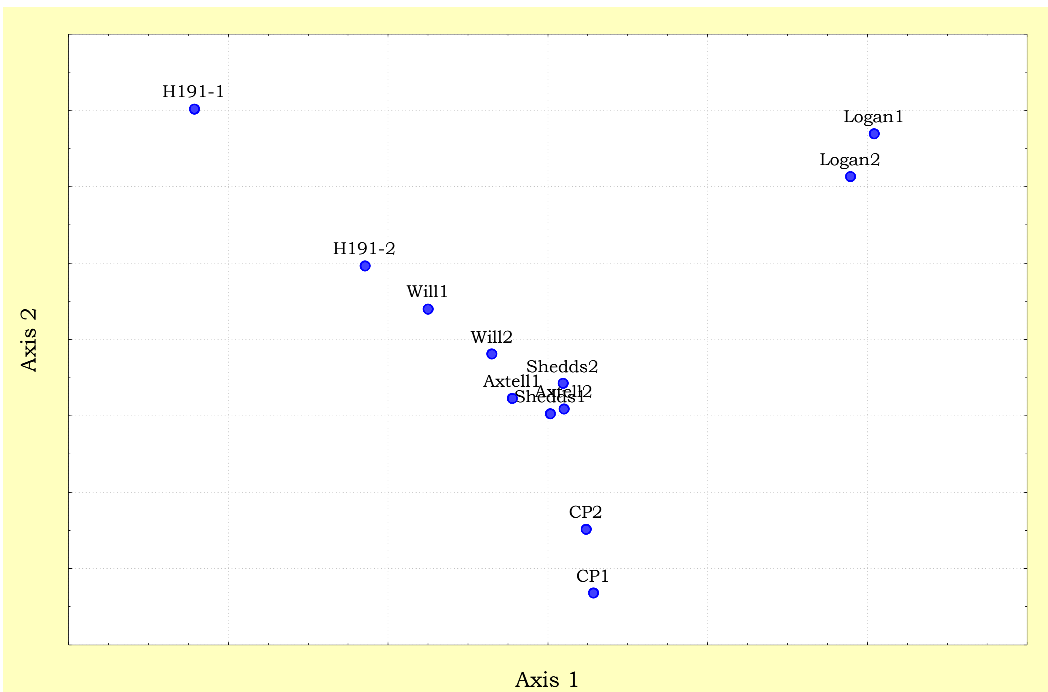
On South Cottonwood Creek, scores diminish from non-impaired biology and full use support at the upstream site to the downstream site, a typical pattern. But the degree of impairment at Gooch, the lowermost site, is notable. Scores here indicate non-support of designated uses and moderate impairment. At the intermediate site (Law) partial use support and slight impairment are suggested.

Aquatic invertebrate communities

Interpretations of biotic integrity in this report are made without reference to results of habitat assessments, or any other information about the sites or watersheds that may have accompanied the invertebrate samples. Interpretations are based entirely on: the taxonomic and functional composition of the sampled invertebrate assemblages; the sensitivities, tolerances, physiology, and habitus information for individual taxa gleaned from the writer's research; the published literature, and other expert sources; and on the performance of bioassessment metrics, described earlier in the report, which have been demonstrated to be useful tools for interpreting potential implications of benthic invertebrate assemblage composition.

Figure 3 is an ordination plot of the aquatic invertebrate assemblages sampled from the 6 sites on the Gallatin River in 2002. All replicates are graphed. Ordination is a graphical technique that results in an arrangement of the assemblages such that similar ones are placed close together in two-dimensional space, and dissimilar assemblages are placed farther apart. Similarity in this case is based on the relative abundance of each taxon in each replicate sample. The plot is intended to demonstrate the similarity between replicates relative to the similarity among sites. It was not possible to generate such a diagram for South Cottonwood Creek samples, since there were too few samples taken there to generate a meaningful ordination.

Figure 3. Ordination (Principal Components Analysis) of assemblages sampled from the Gallatin River September 2002. Gallatin River replicates are indicated by blue dots.



The ordination demonstrates the similarity of assemblages in replicates at all of the Gallatin River sites except for the Highway 191 site, which yielded relatively dissimilar replicates. High similarity of assemblages taken in multiple samples from a single site is a desirable sampling outcome; evidence for differences among sites is manifested by comparing among-site dissimilarities to between-replicate dissimilarities. In the case of the Highway 191 site, dissimilarities between the 2 replicates taken there appear to be largely due to the numbers of the blackfly *Simulium* sp. collected in each. Unfortunately, large numbers of this gregarious animal may be collected serendipitously when the sampler randomly encounters a large aggregation of animals on a particular rock. *Simulium* sp. often confounds sample analysis in this way. The plot also shows the notable similarity among the Williams bridge, Axtell bridge, and Shedds bridge sites, which exhibited just as much among-site similarity as the between-replicate similarity at each site.

Assemblages of the Gallatin River sites

At the Highway 191 bridge, the mean biotic index value (μ = 4.26) calculated for the 2 replicate samples was somewhat higher than expected; however, a total of 6 mayfly taxa were collected at the site. These findings are contradictory, but suggest that mild nutrient pollution may limit water quality at the site. Thirty-four percent of the organisms taken in the replicate samples were midges, and the blackfly *Simulium* sp. was also abundant in this reach. This evidence adds strength to the hypothesis that slight degradation to water quality affects the benthic invertebrate assemblage here. The site supported at least 13 "clinger" taxa and 7 caddisfly taxa, implying that clean stony substrates were substantially free from fine sediment deposition. Other instream habitats appear to have been abundantly available, since taxa richness in both replicates (μ = 33.5) was high, and predator taxa were amply represented (μ = 6 taxa). Mean stonefly richness in replicates was 2.5 taxa; four taxa in all were collected but none were abundant. Stonefly richness may be associated with the integrity of reach-scale habitat features such as riparian zone function, streambank stability, and natural channel morphology. The mildly depressed representation of this group in samples suggests that minimal alterations to habitat on a large scale may influence the composition of the benthos. Seven long-lived taxa were collected, implying that surface flow persisted year-round, and that no catastrophes recently limited life cycles in this reach. All expected functional components of a healthy riverine system were present at the site in proportions expected for a riverine system. Collectors and filter-feeders dominated the functional mix, and a moderately large component of shredders was present; scrapers were not abundant.

Water quality indicators exhibited some improvement at the Williams bridge site, where the mean biotic index value for replicated samples was 3.12. While mean mayfly richness was only 5 taxa, the site supported at least 7 Ephemeroptera species. Water quality was probably within expectations for a riverine site, and was perhaps somewhat better than at the upstream site near the Highway 191 bridge. Numbers of "clinger" (μ = 14) and caddisfly (μ = 6) taxa were ample enough to suggest that fine sediment deposition did not substantially impair the availability of stony substrate habitats. Mean taxa richness (29.5) for the replicates was adequate, and predator richness was high (μ = 5 taxa) though the abundance of predatory taxa was not (μ = 2.45%); instream habitats were probably amply available, but perhaps somewhat monotonous. The site supported at least 5 stonefly taxa, and mean richness of this group for replicates was 3.5 taxa. This implies that reach-scale habitat features may have been essentially intact. Seven semivoltine taxa were among the sampled assemblage; no disasters such as dewatering or toxic inputs limited long life cycles in this reach. The functional composition of the benthos was dominated by shredders, in particular the caddisfly *Lepidostoma* sp., which seems to be persistently abundant in the lower reaches of the Gallatin River. Collectors and filterers compose another significant portion of the functional mix, which seems to be entirely consistent with expectations for a riverine community.

Good water quality appears to have persisted downstream at the Axtell bridge site, where the mean biotic index value (3.43) calculated for replicates was within presumed limits for a large river. Adequate mayfly taxa richness (μ = 5.5 taxa) adds evidence for essentially unimpaired water quality. Sediment deposition does not seem to have had a major impact on substrate habitat availability, since mean "clinger" richness was 12 taxa, and caddisflies were also diverse (μ = 5.5 taxa). Taxa richness (μ = 25.5) was somewhat depressed, perhaps because of monotonous instream habitats. Predators, however, showed fairly good diversity; six taxa were collected. Very few stoneflies were taken in replicate samples; only 3 taxa were present. This suggests that reach-scale habitat may have suffered enough disturbance to affect instream biota. Such disturbance may have involved loss of streambank stability or natural channel morphology, or disruption of riparian zone function. Long-lived taxa fare well at this site; in all, 6 semivoltine taxa were collected in replicate samples. Perennial flow conditions have apparently remained adequate to support these animals. The functional mix demonstrated the same preponderance of shredders as that of the upstream site at Williams bridge. Once again, the assemblage was dominated by the caddisfly *Lepidostoma* sp., which overwhelmed one of the replicates collected here. As anticipated for riverine benthos, collectors and filterers were also abundant.

The biotic index value (μ = 1.92) calculated for the assemblage sampled at Shedd's bridge appears to represent a precipitous change from that of sites upstream. However, the calculation is skewed by the overwhelming dominance of *Lepidostoma* sp. at the site. When the metric is refigured excluding this caddisfly, the remaining elements of the assemblage are seen to be generally more tolerant; the biotic index increases to a mean of 4.48 for the replicates. A single representative of a warmer-water taxon, *Helicopsyche borealis*, a caddisfly, appeared at this site. Nonetheless, the rich mayfly fauna (8 taxa between replicates) is evidence that water quality at the site was appropriately good for a large river. Means of 9.5 "clinger" taxa and 4 caddisfly taxa suggest that fine sediment deposition may limit the availability of hard benthic substrates for colonization. Taxa richness is lower than expected at this site (μ = 24) and predators make up a small component of the assemblage. Monotonous instream habitats could explain these findings, but such monotony may reflect natural conditions in a riverine environment. Disruption of reach-scale habitat features may account for the low richness of stonefly taxa; only 2 taxa were collected. Riparian zone function, streambank stability, channel morphology, or other habitat elements may exhibit disturbances. Collected animals included 4 long-lived taxa, which would probably not be present if surface flow had been interrupted by dewatering or drought, or if toxic pollutants had been introduced. Functionally, the assemblage was dominated by shredders, and this group was limited to a single taxon, *Lepidostoma* sp.

Five taxa that prefer warmer water temperatures appear at the Gallatin River site at Central Park, but none are abundant; they include the caddisflies *Cheumatopsyche* sp. and *Oecetis* sp., and the aquatic moth *Petrophila* sp. Biotic index values (μ = 2.63) were low, but once again replicates were overwhelmed by *Lepidostoma* sp. Without the caddisfly, biotic index values were higher (μ = 4.45). The other water quality indicator gave positive results; mean mayfly taxa richness for replicates was 6, but the site supported at least 9 taxa. These findings suggest that water quality was good, but temperatures appear to have warmed compared to upstream sites. "Clinger" richness (μ = 11.5 taxa) and caddisfly richness (μ = 4.5) compare favorably with the results from other Gallatin River sites and indicate that fine sediment deposition did not appreciably contaminate benthic substrate habitats. Though there was a notable diversity of predatory taxa (8 between replicates), they represent a small proportion of collected animals. Taxa richness (μ = 28) was somewhat higher than at Shedd's bridge, but some monotony of instream habitats is suggested. Stonefly richness (μ = 2.5) was lower than expected, and may indicate disturbances to reach-scale habitat features. Similar to the other Gallatin River sites, small numbers of several semivoltine taxa were present in the sampled assemblage, suggesting that year-round surface flow has been the rule in this reach. The functional mix of the benthos collected here includes a major shredder component, and the expected collectors and filterers make up most of the other functional elements.

As the ordination plot in Figure 5 suggests, the benthic assemblage collected at Logan was distinctly different from any other collected in this study, both taxonomically and functionally. Water quality indicators suggested that nutrient enrichment was not a major impairment at this site, but taxonomic evidence of warm water temperatures was apparent. The caddisfly *Helicopsyche borealis* dominated both replicates, and other taxa that prefer warmer temperatures were also collected, such as the mayfly *Stenonema* sp., the beetle *Microcylloepus* sp., and the lepidopteran *Petrophila* sp. Numerous "clinger" taxa (μ = 15.5) and a rich caddisfly fauna (μ = 5 taxa) suggest that fine sediment deposition did not substantially limit benthic habitats at the site. Overall taxa richness was high; a mean of 31.5 taxa for replicates was calculated, but predatory taxa were not particularly diverse, nor were they abundant. These findings present contradictory evidence with regard to the diversity and availability of instream habitats, and no conclusion can be drawn. Stoneflies were scarce at the site; only a single taxon was collected. Reach-scale habitat features such as channel morphology, streambank integrity, or riparian zone function may be disturbed. At least 5 long-lived taxa were supported here, suggesting that dewatering or other catastrophes have not recently limited life cycles in this reach. Functionally, the Gallatin River benthos appears to experience a dramatic shift from shredder-dominance to scraper-dominance in the reach between Central Park and Logan. Scrapers made up 57% of sampled organisms at this site, while contributing insignificant portions to the functional composition of all other sampled Gallatin River sites. It is possible that warmer water temperatures foster the growth of algal films in this reach; reduced shading or less turbidity could also invigorate growth.

Assemblages of the South Cottonwood Creek sites

At the uppermost sampled site on South Cottonwood Creek (at Trail bridge), a low mean biotic index value (2.95) and high mayfly taxa richness ($\mu = 10$) suggest that clean water provided the matrix for the benthic assemblage. No fewer than 8 cold-stenotherm taxa were present at the site, including the stoneflies *Megarcys* sp. and *Yoraperla* sp. Cold water, unimpaired by nutrients or other pollutants appears to have been the rule here. Twenty-two "clinger" taxa were present in each of the replicate samples, and at least 10 caddisfly taxa were supported at the site. These findings suggest that benthic substrate habitats were unimpaired by fine sediment deposition. Overall taxa richness ($\mu = 45.5$) and a diverse predator fauna ($\mu = 11.5$ taxa) imply the abundance and availability of an assortment of other habitats as well. Hyporheic spaces appear to have been among the available habitats, since the stoneflies *Paraperla* sp. and *Despaxia augusta* were collected here. The diversity of stoneflies was good enough to imply that reach-scale habitat features were probably intact. Long-lived taxa were present, suggesting year-round surface flow. The functional composition of the sampled assemblage included all expected components of a healthy montane stream community.

One of the replicates collected at the Law Road site had a low abundance of organisms, but the other sample produced an adequate number of animals for the analysis. For that sample, the calculated biotic index value (2.28) was within expectations for a montane stream, and mayfly taxa richness (5) was high enough to conclude that water quality was essentially good at the site. A single cold-stenotherm taxon was collected, suggesting that water temperatures may have been somewhat higher here than at the upstream site at Trail bridge. Sixteen "clinger" taxa and 7 caddisfly taxa were present in the sample; fine sediment deposition was probably not a significant limitation to benthic community integrity. Other instream habitats appear to have been diverse and available, since taxa richness (33) was high, and the site supported at least 7 predatory invertebrate taxa. Samples yielded 4 stonefly taxa, but none of these was abundant; two taxa were represented by single individuals. Whether this scarcity of stoneflies is related to reach-scale disturbances is unclear. Long-lived taxa (5) were common at this site, suggesting that surface flow persisted year-round and there were no recent catastrophic interruptions to semivoltine life cycles. Functionally, the assemblage was composed of the expected groups in appropriate proportions. Scrapers, shredders, and gatherers were the dominant components of the functional mix.

The sampled assemblage at Gooch Hill Road produced the lowest bioassessment scores of all sites in this study. High biotic index value ($\mu = 5.17$) and low mayfly richness (3 taxa in combined replicates) suggest that water quality impairment likely limited biotic integrity at the site. Warm water and nutrient enrichment appear to be likely impacts. The mayfly *Centroptilum* sp. and the lymnaeid snail *Fossaria* sp. were both common at the site; each of these prefers relatively warm water temperatures. No cold-stenotherms were present in samples, and no sensitive taxa were collected. Fine sediment deposition likely limited benthic habitats, since there was evidence of only 2 caddisfly taxa and 3 "clinger" taxa. One of the "clingers" was the blackfly *Simulium* sp., which dominated both replicates. This larva is gregarious, and tends to occupy leading edges of stony substrate particles which are least likely to be obliterated by sediment deposition. As a result of the large relative abundance of this animal in the sampled assemblage, the functional mix here was skewed toward filter-feeders. This implies that an ample supply of fine organic particulates was a major energy source for the invertebrate community here. The low taxa richness and poor contribution of predators to the composition of the assemblage hints at monotonous instream habitats. A single immature perlodid made up the stonefly contingent; reach-scale habitat features may have been disrupted. Long-lived taxa were notably underrepresented at this site, suggesting that dewatering or other life cycle interruptions may have been recent or even perennial challenges to biotic integrity.

CONCLUSIONS – 2002

- Mild nutrient enrichment is suggested by biotic index values at the Highway 191 crossing of the Gallatin River.
- Disruptions to reach-scale habitat features may be present at the Highway 191 crossing, Axtell bridge, Shedd's bridge, Central Park, and Logan sites; low stonefly taxa richness may be associated with disturbances to streambank integrity, riparian zone function, or natural channel morphology.
- At Williams bridge, invertebrate assemblages appeared to indicate good water quality and minimal habitat disturbances.
- Evidence for mild effects of fine sediment deposition may have been present in the taxonomic composition of the assemblage collected at Shedd's bridge.
- Animals preferring warm water temperatures appeared at the Central Park site, and persisted downstream at the Logan site.
- On South Cottonwood Creek, the Trail site supported a sensitive, diverse, cold-water assemblage characteristic of minimally disturbed montane streams.
- Good water quality and warming temperatures may have characterized conditions at Law Road.
- At Gooch Hill Road, benthic habitats may have been limited by fine sediment deposition, and evidence of warm water temperatures and nutrient enrichment could be found in the taxonomic composition of the sampled assemblage. Dewatering or other catastrophes may have been recent impacts.
- The bioassessment method applied to these data appears to have some limitations to the accurate evaluation of riverine sites. Originally designed for second-to-fourth order streams, the assessment criteria appear to overestimate impairment for riverine sites. In particular, the Sensitive Taxa Richness and Percent Tolerant Taxa metrics should probably be re-evaluated, and scoring criteria for all metrics revised to better apply to riverine conditions.

Table 5a. Metric values, scores, and bioassessments for reliplicate samples taken at six sites on the Lower Gallatin River. September 2002. Sites are described in Table 1.

	SITES											
	Highway 191		**Williams**		**Axtell**		**Shedd's**		**Central Park**		**Logan**	
REPLICATE	1	2	1	2	1	2	1	2	1	2	1	2
METRICS	**METRIC VALUES**											
Ephemeroptera richness	5	6	6	4	7	4	5	6	8	4	6	6
Plecoptera richness	1	4	5	2	3	1	2	0	3	2	1	0
Trichoptera richness	6	5	6	6	6	5	4	4	5	4	5	5
Number of sensitive taxa	2	2	2	2	0	1	0	1	1	0	0	0
Percent filterers	27	15	25	19	28	4	1	14	6	15	20	16
Percent tolerant taxa	17	16	11	14	10	3	4	5	4	11	75	85
	METRIC SCORES											
Ephemeroptera richness	2	3	3	2	3	2	2	3	3	2	3	3
Plecoptera richness	1	3	3	2	2	1	2	0	2	2	1	0
Trichoptera richness	3	3	3	3	3	3	2	2	3	2	3	3
Number of sensitive taxa	2	2	2	2	0	1	0	1	1	0	0	0
Percent filterers	0	1	1	1	0	3	3	1	2	1	1	1
Percent tolerant taxa	1	1	1	1	2	3	3	3	3	1	0	0
TOTAL SCORE (max.=18)	9	13	13	11	10	13	12	10	14	8	8	7
PERCENT OF MAX.	**50**	**72**	**72**	**61**	**56**	**72**	**67**	**56**	**78**	**44**	**44**	**39**
Impairment classification*	**MOD**	**SLI**	**SLI**	**SLI**	**SLI**	**SLI**	**SLI**	**SLI**	**SLI**	**MOD**	**MOD**	**MOD**
USE SUPPORT †	**PART**	**PART**	**PART**	**PART**	**PART**	**PART**	**PART**	**PART**	**FULL**	**PART**	**PART**	**PART**

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.
† Use support designations: See Table 3a.

Table 5b. Metric values, scores, and bioassessments for replicate samples taken at three sites on South Cottonwood Creek. September 2002. Sites are described in Table 1.

	SITES					
	Trail		Law		Gooch	
REPLICATE	1	2	1	2	1	2
METRICS	**METRIC VALUES**					
Ephemeroptera richness	10	10	0	5	3	2
Plecoptera richness	7	7	1	4	1	1
Trichoptera richness	7	8	3	7	1	1
Number of sensitive taxa	8	8	2	1	1	0
Percent filterers	<1	2	0	4	58	61
Percent tolerant taxa	5	5	24	12	17	16
	METRIC SCORES					
Ephemeroptera richness	3	3	0	2	1	1
Plecoptera richness	3	3	1	3	1	1
Trichoptera richness	3	3	2	3	0	0
Number of sensitive taxa	3	3	2	1	1	0
Percent filterers	3	3	3	3	0	0
Percent tolerant taxa	3	3	1	1	1	1
TOTAL SCORE (max.=18)	18	18	9	13	4	3
PERCENT OF MAX.	**100**	**100**	**50**	**72**	**22**	**17**
Impairment classification*	**NON**	**NON**	**MOD**	**SLI**	**MOD**	**SEV**
USE SUPPORT †	**FULL**	**FULL**	**PART**	**PART**	**NON**	**NON**

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b. † Use support designations: See Table 3a.

YEAR-TO-YEAR VARIATION IN RESULTS

Habitat assessment

Figure 4 compares total habitat assessment scores for sites that were visited in both years. Table 6 (a, b, and c) itemizes the evaluated habitat parameters and shows the assigned scores for each. In general, similar scores are expected from one year to the next, assuming that intense disturbance events did not occur in the intervening time. Such events might be natural, such as fire and subsequent sediment inputs, or anthropogenic, such as road building or intensification of cattle grazing. Huge improvement in overall habitat assessment scores would be unexpected, except in unusual circumstances. For example, flood conditions and scouring flow could result in a reduction of deposited sediment, or destabilized streambanks can be shored up with gabions or rip-rap. Only one of the evaluated habitat measures, Channel Flow Status, can be expected to change significantly from one year to the next, assuming that stream reconstruction or natural disasters did not occurred in the intervening time. In fact, improvement in flow conditions were apparently assessed at the Shedd's bridge site in 2002.

Other habitat features are slower to change in what are accepted to be positive ways. Assuming that the same sites are revisited, an examination of year-to-year variation in habitat assessment results can be a measure of the precision of the evaluation. The possibility of a lack of precision is a frequently-cited pitfall of such subjective assessments.

Thus, Figure 4 shows the expected consistency in total habitat assessment scores in revisited sites for nearly all of the locations included in the study. Table 6 (a, b, and c) demonstrate that, with a few exceptions, the evaluation of individual measures gave fairly precise results; that is, field personnel were able to provide repeatable data, implying reliable observational skills. Notable, however, are the results for the site at Logan, where there was a 54% increase in the total habitat assessment score between 2001 and 2002.

Several measures evaluated at Logan were assigned significantly different scores in 2002; these include Benthic Substrate, Embeddedness, Channel Alteration, Sediment Deposition, and Vegetated Zone Width. All of these measures apparently improved greatly by the second year; there is no reasonable explanation for these changes, assuming that the visited location was exactly the same in both years. The slight difference in the GPS readings between the 2 years suggests that the sampling location may have been relocated in the second year.

Figure 4. Comparison of total habitat assessment scores from 2001 and 2002 for six sites on the Gallatin River and one site on South Cottonwood Creek. September 2001 and 2002.

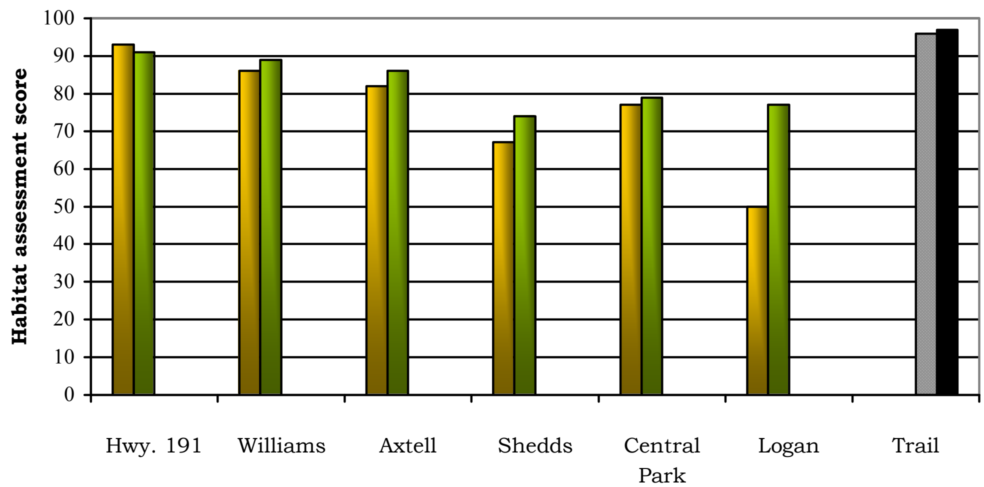


Table 6a. Stream and riparian habitat assessment. Three sites on the Lower Gallatin River. September 2001 and 2002.

Max. possible score	Parameter	Hwy 191 2001	Hwy 191 2002	Williams 2001	Williams 2002	Axtell 2001	Axtell 2002
10	Riffle development	10	9	10	9	5	8
10	Benthic substrate	9	10	9	10	8.5	9
20	Embeddedness	18	18	18	19	17	19
20	Channel alteration	20	20	19	20	16	15
20	Sediment deposition	20	19	18	18	15.5	19
20	Channel flow status	18	18	14	16	15	15
20	Bank stability: left / right	10 / 10	9 / 8	9 / 5	10 / 8	8 / 8	8 / 9
20	Bank vegetation: left / right	10 / 10	9 / 8	9 / 9	8 / 6	9 / 9	9 / 9
20	Vegetated zone: left / right	5 / 9	8 / 10	9 / 9	9 / 9	10 / 10	9 / 9
160	Total	149	146	138	142	131	138
	Percent of maximum CONDITION*	**93%** **OPT**	**91%** **OPT**	**86%** **OPT**	**89%** **OPT**	**82%** **OPT**	**86%** **OPT**

*Condition categories: Optimal (OPT) > 80% of maximum score; Sub-optimal (SUB) ; 75 - 56%; Marginal (MARG) 49 - 29%; Poor <23%. Adapted from Plafkin et al. 1989.

Table 6b. Stream and riparian habitat assessment. Three sites on the Lower Gallatin River. September 2001 and 2002.

Max. possible score	Parameter	Shedd's 2001	Shedd's 2002	Central Park 2001	Central Park 2002	Logan 2001	Logan 2002
10	Riffle development	5	7	8	9	4	4
10	Benthic substrate	8	8	9	10	4	9
20	Embeddedness	15.5	17	18	18	3	17
20	Channel alteration	15	13	20	18	13	18
20	Sediment deposition	15	15	16	16	8	17
20	Channel flow status	10	16	13	12	15	18
20	Bank stability: left / right	8 / 9	9 / 10	10 / 5	8 / 5	9 / 5	9 / 5
20	Bank vegetation: left / right	2 / 9	5 / 7	9 / 5	9 / 6	5 / 5	6 / 6
20	Vegetated zone: left / right	3 / 7	2 / 9	10 / 0	9 / 6	5 / 4	5 / 9
160	Total	106.5	118	123	126	80	123
	Percent of maximum CONDITION*	**67%** **SUB**	**74%** **SUB**	**77%** **SUB**	**79%** **OPT**	**50%** **MARG**	**77%** **SUB**

*Condition categories: Optimal (OPT) > 80% of maximum score; Sub-optimal (SUB) ; 75 - 56%; Marginal (MARG) 49 - 29%; Poor <23%. Adapted from Plafkin et al. 1989.

Table 6c. Stream and riparian habitat assessment. One site on South Cottonwood Creek. September 2001 and 2002.

Max. possible score	**Parameter**	**Trail 2001**	**Trail 2002**
10	Riffle development	10	10
10	Benthic substrate	10	10
20	Embeddedness	20	19
20	Channel alteration	19	19
20	Sediment deposition	20	19
20	Channel flow status	15	18
20	Bank stability: left / right	10 / 10	10 / 10
20	Bank vegetation: left / right	10 / 10	10 / 10
20	Vegetated zone: left / right	10 / 10	10 / 10
160	Total	154	155
	Percent of maximum CONDITION*	**96% OPT**	**97% OPT**

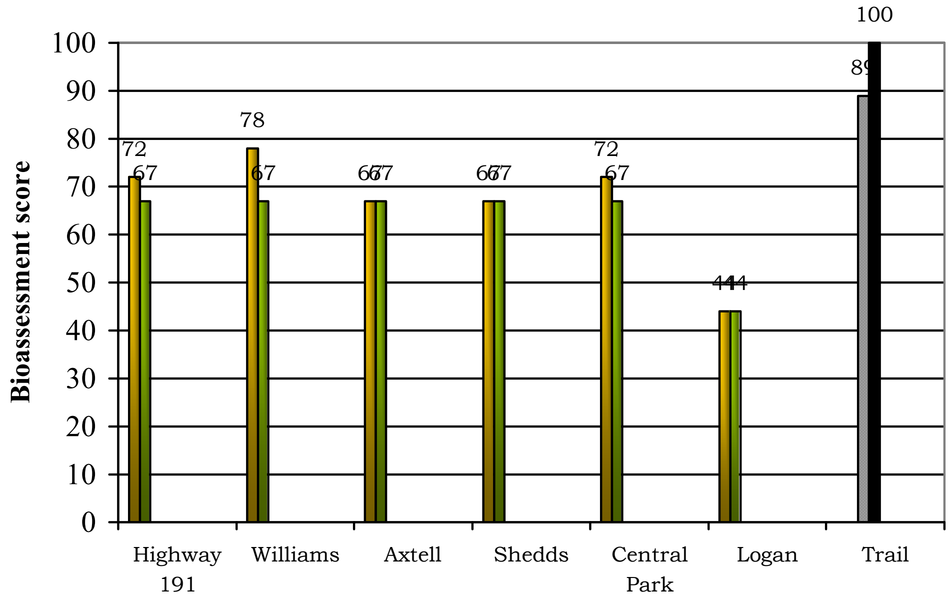
*Condition categories: Optimal (OPT) > 80% of maximum score; Sub-optimal (SUB); 75 - 56%; Marginal (MARG) 49 - 29%; Poor <23%. (Plafkin et al. 1989).

Bioassessment

Figure 5 compares total bioassessment scores for sites that were visited in both years. Table 7 (a, b, and c) itemizes the evaluated bioassessment metrics and shows values and assigned scores for each. Ideally, integrated bioassessment metric batteries are not expected to show significant year-to-year variation unless the watershed experiences changes in water quality and/or habitat features in the intervening time. Varying flow conditions would also be anticipated to affect metric performance and total bioassessment outcomes. For many metric batteries, including the one used in this study, year-to-year variation absent significant changes in habitat or water quality has not been adequately investigated.

As Figure 7 demonstrates, there were significant changes (>10%) in bioassessment scores at 2 of the studied sites between the 2 years. On the Gallatin River at Williams bridge, total scores declined 14%, and on South Cottonwood Creek at Trail, scores increased 12%. The Williams bridge data may have an additional source of variation; in 2001, inadequate sample sizes made it necessary to combine replicate samples. Total bioassessment score was calculated for metrics derived from the single composited sample. In 2002, the total bioassessment score was calculated for averaged metrics derived from 2 replicates. Ephemeroptera taxa richness and the number of sensitive taxa both declined in 2002 from 2001 counts. Both metrics are regarded in this study to be reflections of water quality. The biotic index is another measure associated with water quality; its value did not change between the 2 years. Whether the variation in metric values and scores can be explained by the differences in the procedures applied to sample handling is not clear. Slight impairment of biotic health was indicated by total scores in both years.

Figure 5. Total bioassessment scores for six sites on the Lower Gallatin River and one site on South Cottonwood Creek, September 2001 and 2002. Total scores are based on average metric values for two replicate samples, except for the 2001 Highway 191 and Williams bridge sites. Because of inadequate sample sizes, replicates were combined, and scores were based on the resulting composites. Sites are described in Table 1.



On South Cottonwood Creek at Trail, variation in the performance of a single metric, Percent Tolerant Taxa, accounts for the variation in total bioassessment score between the 2 years. In fact, metric performance variation in this case is accounted for by a single taxon, the mayfly *Baetis tricaudatus*. This animal is classified as a tolerant taxon, but perhaps tolerance to pollutants is confused with simple ubiquity in its case. In any event, baetid mayflies were represented by this single taxon in 2001, but there was apparently some species replacement in 2002. In that year, significant numbers of the cold-stenotherm *Baetis bicaudatus* appeared at the Trail site. In both years, bioassessment scores suggest that this site was virtually unimpaired biologically.

It appears, then, that year-to-year variation in total bioassessment scores at these sites was minimal in the 2 years of this study. Sites which yielded total scores that differed by more than 10% in the 2 years still yielded identical impairment classifications. Circumstances associated with sample handling or an unfairly maligned taxon could account for the differences, and suggest ways in which year-to-year variability might be minimized.

Table 7a. Metric values, scores, and bioassessments for three sites on the Lower Gallatin River. September 2001 and 2002. Assessment classifications and use support designations in parentheses are tentative, since they are based on combined replicates, none of which contained adequate numbers of organisms for the analysis. Sites are described in Table 1.

SITE	Highway 191			Williams			Axtell			
SAMPLING YEAR	2001	2002		2001	2002		2001		2002	
REPLICATE	Composite	1	2	Composite	1	2	1	2	1	2
METRICS	**METRIC VALUES**									
Ephemeroptera richness	5	5	6	7	6	4	6	5	7	4
Plecoptera richness	4	1	4	5	5	2	1	2	3	1
Trichoptera richness	5	6	5	7	6	6	7	5	6	5
Number of sensitive taxa	4	2	2	6	2	2	0	1	0	1
Percent filterers	12	27	15	19	25	19	2	15	28	4
Percent tolerant taxa	13	17	16	18	11	14	4	10	10	3
	METRIC SCORES									
Ephemeroptera richness	2	2	3	3	3	2	3	2	3	2
Plecoptera richness	3	1	3	3	3	2	1	2	2	1
Trichoptera richness	3	3	3	3	3	3	3	3	3	3
Number of sensitive taxa	3	2	2	3	2	2	0	1	0	1
Percent filterers	1	0	1	1	1	1	3	1	0	3
Percent tolerant taxa	1	1	1	1	1	1	3	2	2	3
TOTAL SCORE (max.=18)	13	9	13	14	13	11	13	11	10	13
PERCENT OF MAX.	**72**	**50**	**72**	**78**	**72**	**61**	**72**	**61**	**56**	**72**
Impairment classification*	**(SLI)**	**MOD**	**SLI**	**(SLI)**	**SLI**	**SLI**	**SLI**	**SLI**	**SLI**	**SLI**
USE SUPPORT †	**(PART)**	**PART**	**PART**	**(FULL)**	**PART**	**PART**	**PART**	**PART**	**PART**	**PART**

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b. † Use support designations: See Table 3a.

Table7b. Metric values, scores, and bioassessments for three sites on the Lower Gallatin River. September 2001 and 2002. Sites are described in Table 1.

SITE	Shedd's				Central Park				Logan			
SAMPLING YEAR	**2001**		**2002**		**2001**		**2002**		**2001**		**2002**	
REPLICATE	1	2	1	2	1	2	1	2	1	2	1	2
METRICS	**Metric Values**											
Ephemeroptera richness	6	8	5	6	2	3	8	4	4	5	6	6
Plecoptera richness	1	3	2	0	2	2	3	2	1	1	1	0
Trichoptera richness	5	4	4	4	5	5	5	4	6	5	5	5
Number of sensitive taxa	2	2	0	1	0	1	1	0	0	0	0	0
Percent filterers	10	17	1	14	5	4	6	15	14	2	20	16
Percent tolerant taxa	9	12	4	5	4	4	4	11	70	92	75	85
	Metric Scores											
Ephemeroptera richness	3	3	2	3	1	1	3	2	2	2	3	3
Plecoptera richness	1	2	2	0	2	2	2	2	1	1	1	0
Trichoptera richness	3	2	2	2	3	3	3	2	3	3	3	3
Number of sensitive taxa	2	2	0	1	0	1	1	0	0	0	0	0
Percent filterers	1	1	3	1	3	3	2	1	1	3	1	1
Percent tolerant taxa	2	1	3	3	3	3	3	1	0	0	0	0
TOTAL SCORE (max.=18)	12	11	12	10	12	13	14	8	7	9	8	7
PERCENT OF MAX.	**67**	**61**	**67**	**56**	**67**	**72**	**78**	**44**	**39**	**50**	**44**	**39**
Impairment classification*	**SLI**	**SLI**	**SLI**	**SLI**	**SLI**	**SLI**	**SLI**	**MOD**	**MOD**	**MOD**	**MOD**	**MOD**
USE SUPPORT †	**PART**	**PART**	**PART**	**PART**	**PART**	**PART**	**FULL**	**PART**	**PART**	**PART**	**PART**	**PART**

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b. † Use support designations: See Table 3a.

Table 7c. Metric values, scores, and bioassessments for one site on South Cottonwood Creek. September 2001 and 2002. Sites are described in Table 1.

SITE	Trail			
SAMPLING YEAR	2001		2002	
REPLICATE	1	2	1	2
METRICS	Metric Values			
Ephemeroptera richness	11	8	10	10
Plecoptera richness	7	6	7	7
Trichoptera richness	9	7	7	8
Number of sensitive taxa	6	6	8	8
Percent filterers	1	1	<1	2
Percent tolerant taxa	16	19	5	5
	Metric Scores			
Ephemeroptera richness	3	3	3	3
Plecoptera richness	3	3	3	3
Trichoptera richness	3	3	3	3
Number of sensitive taxa	3	3	3	3
Percent filterers	3	3	3	3
Percent tolerant taxa	1	1	3	3
TOTAL SCORE (max.=18)	16	16	18	18
PERCENT OF MAX.	**89**	**89**	**100**	**100**
Impairment classification*	**NON**	**NON**	**NON**	**NON**
USE SUPPORT †	**FULL**	**FULL**	**FULL**	**FULL**

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b. † Use support designations: See Table 3a.

Aquatic invertebrate assemblages

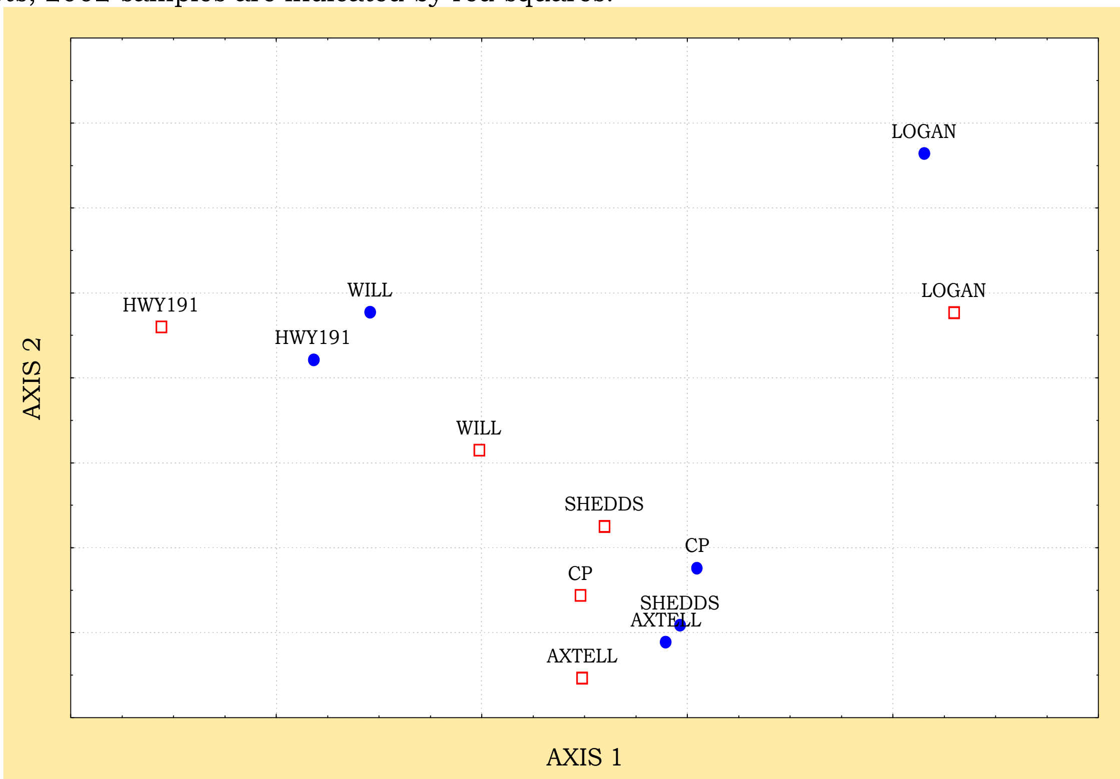
Gallatin River assemblages

Figure 6 is an ordination plot of the aquatic invertebrate assemblages sampled from sites on the Gallatin River in both 2001 and 2002. Symbols distinguish the year in which a sample was collected.

Distinctive assemblages were collected at Highway 191and Williams bridge. In both years these sites were unique among lower Gallatin River sites in their support of *Cricotopus nostococladius*, a midge that participates in a mutualistic relationship with the blue-green algae *Nostoc* sp., and the mayfly *Drunella doddsi*. All three of these organisms require cold, clean water. Apparently, conditions favoring this biota diminish in the Gallatin River reaches between Williams bridge and Axtell bridge.

In 2001, the taxonomic composition of samples collected at Highway 191 and Williams bridge was very similar, but was less so in 2002. The difference in 2002 was mainly due to the increased dominance of the caddisfly *Lepidostoma* sp. at the Williams bridge site. This animal

Figure 6. Ordination (Principal Components Analysis) of sites sampled on the lower Gallatin River in 2001 and 2002. Replicates are combined for this plot. 2001 samples are indicated by blue dots, 2002 samples are indicated by red squares.



was extremely common in both years at all studied sites above Logan. Dominance of *Lepidostoma* sp. within assemblages began at Axtell in 2001, but farther upstream at Williams bridge in 2002. Salmonflies were collected at both Highway 191 and at Williams bridge in 2001, but were not collected at Williams bridge in 2002. The significance of these findings is not clear, and may not signify any interpretable differences in habitat and/or water quality.

Assemblages collected at Axtell, Shedd's, and Central Park were similar to one another in both years. As the ordination plot suggests, both between-site and year-to-year variation in taxonomic composition of assemblages from these sites was relatively small. Generally, samples were characterized by large proportional representations of *Lepidostoma* sp., suggesting that riparian inputs of large organic debris were a major source of energy for functional systems in these reaches. The midge *Cricotopus trifascia* and immature perlodid stoneflies (*Skwala* sp.?) were common denizens of each of these locations, suggesting mildly increased water temperatures compared to the upstream sites. However, there is some evidence that water temperatures in 2001 may have been warmer than in 2002; the tolerant caddisfly *Oecetis* sp. and the mayfly *Tricorythodes minutus* were collected at both Shedd's bridge and at Central Park in 2001, but were only collected at Logan in 2002. In addition, physid snails were found as far upstream as Shedd's in 2001, but occurred only at Logan in 2002. The chloroperlid Sweltsa sp., which had been collected only as far downstream as Axtell in 2001 persisted downstream to Central Park in 2002.

The assemblages collected in both years at Logan had characteristics shared by no other site in either year. Tolerant animals and those that prefer warm water temperatures were more common at this site in both years. *Cheumatopsyche* sp., *Helicopsyche borealis*, and, in

2002, physid snails and *Tricorythodes minutus* were unique to Logan. Elevated temperatures and nutrient enrichment appear to have persisted at Logan in both years of the study. The dissimilarity of assemblages suggested by the ordination plot relate to the greater proportion of *Cheumatopsyche* sp. and lesser contribution of physid snails in 2002 compared to 2001.

The South Cottonwood Creek assemblages at Trail

Excellent water quality and habitat appear to have persisted at the Trail site in both years of the study. Dissimilarities in the assemblages collected at the site in the 2 years of the study are primarily accounted for by the appearance of the sensitive cold-stenotherm *Baetis bicaudatus* in 2002. This animal was not identified in the 2001 samples. The mayfly *Rhithrogena* sp. and the nemourid stonefly *Zapada cinctipes* were both more common in 2001 than in 2002. The implications of these findings are not clear.

CONCLUSIONS

- Similar habitat and water quality conditions appear to have persisted in the lower Gallatin River in 2001 and 2002.
- There is some evidence that water temperatures were somewhat cooler in the middle reaches (Axtell bridge to Central Park) in 2002 compared to 2001.
- Warm water temperatures and nutrient enrichment persisted at Logan in 2001 and 2002.
- The South Cottonwood Creek site at Trail supported a sensitive, cold-stenothermic fauna in both years.

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APPENDIX

Taxonomic data and summaries

The Lower Gallatin River and South Cottonwood Creek

September 2002